Intrinsically Safe Equipment Design

This report was generated after a meeting on the subject with Jan Guldemond of Grinel and conveys the impression that I got on the subject.

Intrinsically Safe equipment is designed in accordance with the following SABS specifications:

Intrinsically Safe Electrical Apparatus - SABS 549-1987
Use of Light Alloys in Mines - SABS 012-1979

The contact at the SABS is a Mr Meyer (referred to as the "explosive" Mr Meyer!). The princple of Intrinsic Safety is that there is never enough electrical energy to cause a spark to ignite an explosive gas.
Intrinsically Safe (IS) requirements may be broken into 3 categories: packaging, battery/power supply, and circuitry.

Packaging:
Whilst under some circumstances light metals such as aluminium are permitted enclosure materials should be restricted to steel and polycarbonate. The equipment should be waterproof to IP67 and it should be noted that mine water is extremely conductive (50 ohms residue across tracks .5mm apart). External keyboards (membrane etc) should connect into a separate enclosure to the electronics and to equalise the pressure a breather plug should be used to allow air (but no moisture) to pass.

The optimal system was suggested to be a polycarbonate enclosure surrounded by a steel package as added protection (not IS but against physical damage).

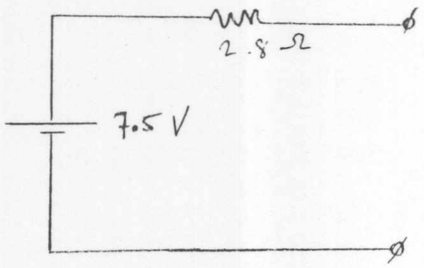
As a film to allow viewing of displays LEXAN polycarbonate films may be used.

In some cases (as with a 220V supply) IS is not possible. It is then necesary to flameproof the equipment in special enclosures with flameproof glands (Pratley). The flameproof enclosures are available from Pratley (Junction boxes etc) which are cheap or Maranata which are larger and more expensive. If the boxes are above a certain size then they must be "compartmentalised".

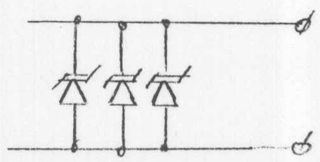
Power Supply:
The power supply must be current limited by an infallible resistor (see spec.) and the temperature of the resistor must be below the ignition point of methane (see graphs). The SABS will take an additional margin of safety for any figure deduced from the graphs. (A figure of 50% was mentioned).

An infallible resistor must be one that fails open circuit. If a wire wound resistor is used for current limiting it must be encased in ceramic so that the coils do not unwind. Welwyn resistors were mentioned as were the cement encased resistors from Kopp and the aluminium finned resistors.

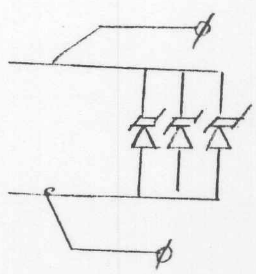
The following circuit is typical of a power supply (used at Grinel):



The heat generated by the resistor from a continuous short circuit across the outputs must be low enough not to ignite a gas of methane. Any other circuitry must be such that there may be two failures without dangerous conditions arising. The test fault, introduced by the testing authority, will always be to the worst possible condition and not the statistically likely (or even guaranteed) failure conditon. The following circuit indicates the use of 3 transzorbs as an overvoltage protection.



good



bad

The actual electrical path is also important as a track failure could also prove to lead to a dangerous conditon. The power supply is reccomended to be potted after manufacture to keep everything in the right place. The potting compound is made by Elite and called ELI-DUR F2 766.

In general the lower the voltage the higher the reliablitly and the lower the resistance with less heat. The minimum creepage distance is 3mm (e.g. the ends of a vertically mounted resistor must be 3mm apart).

Transformers must comply with specific conditions such as withstanding the outputs of the secondary being continuously shorted together without undue temperature increase or loss of isolation from primary to secondary. It was mentioned that the Kopp style PCB mounting tranformers had the desired construction for this.

If linear regulators are used the current limiting should be done after the reservoir capacitors since the requirements are much easier with resistive tests for short circuit. In the case of failure of two components 3 regulators in series may be necessary dropping the voltage in 3 stages. Any of the regulators must be capable of withstanding the full input voltage applied to it without creating dangerous conditions.

Circuitry:
In principle, if the circuitry is fed from an IS supply there is not too much difficulty in attaining IS requirements. The problems lie in capacitive and especially inductive components. In the case of the latter it is assumed that no matter where the actual circuitry exists it is presumed to be across the supply with its limiting resistor. This will obviously generate the maximum backEMF. Included in inductors are loudspeakers, microphones and relays. In capacitive applications the limit is about 47uF at 10V. Paralleling capacitors is not allowed as there is an increase in charge stored.

It would be possible to use inverting voltage generators (using switched capacitors) derived from an IS supply. This circuity should be located away from the rest of the circuitry to prevent the reintialisation of IS protection.

SABS Approval:
Aside from the actual circuitry the SABS requires certain procedures to grant approval. All critical components (principally coils e.g. transformers) must be individually tested at goods in to see that they meet certain requirements. After manufacture the product must pass Quality Assurance and this test is not purely functional but must also include checking critical areas to confirm that the IS specifications are met. Approval is given after inspection and is subject to regular inspections thereafter.

Sundry Data:
Piggy back board connectors:
Harwin (with sideway pins), M20 series

Butting Connectors:
10 way U77U (socket) and U99U (plug) with Plastic shells:
Bernier (France) , Telegartner (Berlin).

Resitor supports: Jermyn